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REPORT

ON A

SYSTEM OF SEWERAGE

FOR THE

CITY OF SAN FRANCISCO.

BY

WILLIAM P. HUMPHREYS,

City and County Surveyor.

MUSEUM OF HYGIENE,
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PLAN FOR A SYSTEM OF SEWERAGE.

OFFICE OF THE CITY AND COUNTY SURVEYOR,
San Francisco, May 22d, 1876.

To the Honorable Board of Supervisors,
City and County of San Francisco:

GENTLEMEN—In accordance with a contract made with your Honorable Body, in November last, by which I was to prepare a system of sewerage for that portion of this City and County in which the grades of the streets have been already established, I have the honor to transmit herewith a general sewerage map of the city, and detailed drawings of sewer connections, manholes, catch basins, and traps; also, detailed plans of house connections with sewers; and I now have the honor to submit the following:

We have no official record of the construction of any public sewer previous to the year 1858. It was in that year their construction was officially commenced, and since that time to July 1st, 1875, there have been constructed $74\frac{37}{100}$ miles of public sewers, at the following cost:

Brick Sewers	$2,252,253 00
Redwood Sewers	378,395 00
Cement Pipe Sewers	54,043 00
Making a total cost of Sewers to July 1st, 1875	$2,684,691 00

A large proportion of which was in currency.

The greater portion of these sewers are of brick, but their cost has been excessive, because, among other reasons, they have been unnecessarily large. The general sizes of the sewers are three (3) feet by five (5) feet. These brick sewers are egg-shaped, as they should be, with the smaller end down. Most of the streets in the older portion of the city have brick sewers, which extend up the hillsides to irregular distances. When these sewers approach the lower portions of the city, when the foundation is not sufficiently solid to sustain a brick sewer without a resort to piling, the sewers are of wood, and are generally level, or nearly level. Being down, or nearly down, to low water, the tide rises and falls in them, so checking their outflow that most of them are to-day nothing more than elongated cess-pools, badly choked with offensive sewage matter. This evil must go on increasing from year to year, until some change is effected and some remedy applied.

In fact, the existing sewers of the city have been built without regard to a system of any kind which looks to the general drainage of the city. Each sewer appears to have been built independently of all others, and without regard to the duty it has to perform. Some of the alleys and short streets in the city, for instance, where there are only a few houses, have sewers of the same size as those in the largest streets, whereas a foot earthenware pipe, at one-fifth the cost of the great brick sewer, would have afforded much more efficient drainage for all such alleys and short streets.

I need scarcely add that the want of system in the existing sewers greatly complicates the problem of designing a proper plan of sewerage for the city,

because, in order to curtail expenses, we are constrained to utilize, as far as possible, the sewers already built, and to reconcile them with those details which more correct principles demand.

THE PROPOSED SYSTEM OF SEWERAGE.

Before undertaking to devise the plan of sewerage for San Francisco, which is now presented for your consideration, in order to fully inform myself on the subject, I carefully studied the systems of sewerage in London and Paris, as well as those of all the principal Eastern cities of the United States.

The water carriage system is adopted in all these cities to the exclusion of "earth closets" or the "pneumatic system." As this is the system now in use in San Francisco, I recommend that it be continued.

In preparing the plan of sewerage now proposed, I have kept constantly in view the following considerations:

1st. The ready conveyance of rain waters and house sewerage to the Bay of San Francisco, with the least possible damage to public or private interests.

2d. The efficient drainage of the sub-soil and foundations of houses.

3d. That all new sewers be so proportioned in size as to admit of further extension to meet all possible future demands, without, at any future time, rendering useless any portion of them which may have been constructed.

4th. The least possible expenditure compatible with a complete and efficient system of sewerage.

5th. The use, therefore, as far as practicable, of all existing sewers.

The topography of this city is divided by Nature into several drainage districts. As an original question, the sewerage districts would correspond with these, but the existence of the present sewers, which it is desirable to utilize, makes some variations necessary.

For convenience of easy references, the sewer districts are designated on the large sewer map by numbers 1, 2, 3, etc., to 30, making altogether that number of districts, one of which includes a portion of the County of San Mateo.

On this map the sizes and the direction of flow of all existing sewers, as well as of those to be built hereafter throughout the city, are shown, so that every property-owner may see at a glance in what sewers he is most interested for the proper drainage of his own premises.

The true purpose of the sewer is the instant removal from the vicinity of dwellings of all refuse matter liable to decomposition and capable of being conveyed by water.

The principle now insisted on, is that each day's sewerage of each street, and of each dwelling, should be removed from the city on the day of its production; that it should pass away before decomposition begins, and that the sewage matter of any one day should not be found within the limits of the city on the next day.

It has already been said that the present brick sewers in the city are, with few exceptions, altogether too large. They are not as efficient as smaller sewers would be, because smaller sewers, with the same grade, would be self-

cleansing, whereas the present large sewers, in many places, have to be entered and cleansed—a disgusting and costly operation which ought never to become necessary in a well arranged system of sewers.

In the plan now proposed I have endeavored to correct these evils. The sizes of the sewers are proportioned to the duty they have to perform.

CONDITIONS GOVERNING THIS QUESTION.

The conditions governing the size of a sewer at any point are these:

1st. The amount of sewage proper passing that point.

2d. The amount of rainfall passing through the sewer at that point in a given time.

3d. The inclination of the sewer.

This brings the question, as to what should be the size of any sewer at any given point away from the regions of speculation, and confines it within the domain of scientific experiment.

The extremes of rainfall within a given time mainly govern the sizes of sewers; the household sewerage is a very small item in comparison.

In the Eastern cities of the United States, where modern sewers have been introduced, it is supposed that the heaviest rainfall is one inch per hour, and it is estimated that not more than one-half of this rainfall reaches the sewers within that hour.

Fortunately for the sizes of the sewers required in this city, we have not to provide for such an excessive rainfall. The heaviest rain of which I find any reliable note is that in the records of Mr. Thomas Tennent. This occurred on the 19th day of December, 1866, when the fall of rain in twenty-four hours was 4.28 inches, or at the rate (nearly) of $\frac{1}{100}$ of one inch per hour for twenty-four hours. It will be safe, therefore, to suppose that the heaviest rainfall in this city will not exceed $\frac{25}{100}$, or $\frac{1}{4}$ of an inch per hour. This is about 39 per cent. more than the heaviest recorded rainfall.

On account of the steep hillsides in many portions of this city, where the water falling on the streets and on the roofs of houses will reach the sewers rapidly, I have increased the proportion of rainfall which will reach the sewers within a given time to sixty (60) per cent. of the total, instead of fifty (50) per cent. in all Eastern cities. This gives $\frac{15}{100}$ of an inch of rainfall within an hour to be provided for by the sewers. A rainfall of one inch deep in one hour, over one acre, gives 3,630 cubic feet of water. Fifteen per cent. of this is 544.5 cubic feet.

The daily flow of sewage for a population of eighty (80) persons per acre, at eight (8) cubic feet each (a very large allowance), will be 640 cubic feet. But one-half of this, or 320 cubic feet, reaches the sewers in eight hours, or at the rate of 40 cubic feet per hour, making the total drainage 584.5 cubic feet per hour for each acre.

As the maximum sewerage per acre per hour (40 cubic feet) is a little over one (1) per cent. of an inch spread out over one acre, and as large buildings, like hotels and manufacturing establishments, may have a population of over eighty persons per acre, I have increased the percentage of an inch per acre,

to seventeen per cent., making 617.10 cubic feet per acre per hour, or 10.285 cubic feet per minute. It is for this amount of discharge per acre per minute that the capacity of the sewers now proposed has been calculated.

SIZES OF THE PROPOSED SEWERS.

In calculating the sizes of the proposed sewers, I have consulted the formulas of Weisbach, D'Aubaison, and Neville, and the sizes have been calculated by the formulas of each of these authors; the final calculations, however, being made by a modification of Weisbach's formula.

RESULTS.

It is found by careful calculations, that with the rainfall and house sewerage given above, that is, $\frac{7}{100}$ of an inch per hour—

A 12-inch	pipe	sewer	with	a	grade	of	1 in	300	will drain 13 acres.
"	"	"	"			1	" 200	"	17 "
"	"	"	"			1	" 150	"	20 "
"	"	"	"			1	" 100	"	25 "
"	"	"	"			1	" 50	"	36 "
"	"	"	"			1	" 25	"	53 "
"	"	"	"			1	" 20	"	59 "

This shows that large areas of the city may be drained by a sewer only 12 inches in diameter. When we come to larger sewers their capacities for drainage increase more rapidly than their sectional areas.

It is upon the proper determination of the sizes of the various sewers that much of the economy of the sewerage sytem of this city must depend. Experience in other cities has fully demonstrated that glazed earthenware pipes, or pipes of Portland cement, of from one foot to one foot six inches in diameter, are well adapted for small sewers, and their use is recommended in the plan now proposed. Even two feet pipe sewers are extensively used in London and in some of the Eastern cities of the United States.

The best earthenware pipe sewers have heretofore been made in Scotland, but if a constant demand for such sewer pipe is created in this and neighboring cities, a good quality of such pipes will doubtless soon be manufactured on this coast.

I know of no city more favorably situated by nature to their general introduction than San Francisco. The steep grades of many of the streets will enable these pipes to drain larger areas than in most other cities.

As we approach the summits of the hills one foot pipes will be amply sufficient. It is only necessary when we must collect the sewerage from very large areas into one sewer that brick sewers will become necessary.

Heretofore, the brick sewers of this city have been built with the common bricks of the country, and it may as well be known that in many cases neither the bricks nor the workmanship have been of the best character. Sewers require the best quality of sand and hard and thoroughly burnt bricks. No sal-

mon bricks should ever be used in a sewer. The inverts of all sewers are particularly liable to wear from the erosion of the water running over them, and in many parts of this city the wear is greatly increased by the grinding action of the sand carried into the sewers in heavy rains.

The bricks in the bottoms of sewers should be smooth, so as to present the least possible frictional resistance to the flow of water. In small brick sewers special bricks or invert blocks should be used in their bottoms, or else bricks with radiating joints should be made to conform to the curve of the bottom of the sewer. Ordinary bricks are totally unfit for the construction of small brick sewers, on account of the wide gaping joints they leave on the back. Unless the mortar, in such a case, is of very superior quality, it will disappear in time, when the water in the sewer will escape through the joints, and the sewer will be liable to become undermined, and thereby destroyed, or it will become filled up with solid matter, which will choke it for want of the water necessary for the transportation of the sewage. The very best quality of cement is required in the construction of sewers. Every barrel should be tested, and the mortar should not be weakened by a too free use of sand.

Both cement and earthenware pipes are now coming into use in this city. If cement pipes continue to be used, only the very best quality of Portland cement should be used in their manufacture, and they should be made some four months before being used. Earthenware pipes should be salt glazed, thoroughly burned and tested as to strength, before being laid in place.

OUTFALL OF SEWERS.

Very few, if any, of the sewers of this city are provided with proper outfalls; whereas all writers on the subject tell us that this is the very first thing that ought to be attended to in designing a system of sewers.

The Bay of San Francisco being of great size, with strong tidal currents, affords great facilities for getting rid of the sewage matter of the city; but to make it available, the sewers must be carried out to points where there are strong currents. If they stop short, the lower parts of the city must always remain in an offensive and unhealthy condition.

Along the busy water-front of the city some of the sewers do not extend out into the bay, but stop short, terminating inside of the rubble stone bulkhead, where the offensive solid matter is deposited, and the liquid matter allowed to escape to the sea as best it can, rendering the slips between the wharves at times offensive to the last degree of endurance. All of these sewers should be carried out to the ends of the wharves, discharging their contents through a bent hood, leading from the outer end of the sewer down below the level of low water. Discharging at such points, the tide will speedily remove the sewage matter away from the city, and there will be no offensive smell about the wharves.

In the construction of new wharves along the water-front, preparations should be made for continuing the sewers under them out to their ends, and also for the protection of the outer ends of the sewers at these points.

It should not be forgotten that there is very little, if any, current in the slips between the wharves, particularly when they are crowded with vessels; and, if the sewers are discharged into these slips, the sewage matter and sand brought down by the sewers is deposited there. The slips soon become very offensive to the sense of smell, and in addition are rapidly filled up, thereby greatly increasing the amount of dredging which is necessary in order to maintain the proper depth of water for berthing vessels.

So serious is this matter of filling up the slips between the wharves, by allowing the sewers to discharge into them, that I seriously contemplated at one time, in the early stages of my investigation into the subject of sewerage for this city, to recommend bringing the entire sewerage of Hayes Valley down Market street to Dupont, then by tunneling Dupont street, from Geary street to the intersection of Dupont street and Montgomery avenue, and continuing the tunnel along the avenue to Greenwich street; a large sewer might be extended through this tunnel along Montgomery avenue to Point San Jose, draining one-half of the city, and discharging the drainage well out towards the sea, thereby greatly relieving the drainage of Mission Bay, and largely decreasing the deposits from the sewers along the city front.

Considerations of cost only induced me to abandon the idea of embodying this project into the plan now proposed.

The sewers now discharging into Mission Bay are, if possible, in even a worse condition; the whole region on the borders of this bay, and along Mission Creek is nearly uninhabitable at low water. Luckily a step has been taken in the right direction to relieve this great nuisance by the construction of a large sewer from Eighteenth street down to Ninth street, capable of carrying all the waters of Mission Creek and all its drainage. When this creek and the bordering low lands above Ninth street are properly filled up and graded, there will be a great improvement in the drainage of this portion of the city; but the outfall of this large sewer will be very imperfect. The nuisance will be concentrated at and below Ninth street, rendering that part of the city offensive at low water.

The proper remedy is to carry this large sewer through Townsend street to the bay. This should be done as soon as funds can be provided for the purpose.

All the outlet sewers in the northern portions of the city should be carried out into the bay, and either empty their contents through closed hoods leading down below low water, or have their outlets closed by a valve. Unless this is done the strong northwest winds of summer will be driven up these sewers in uncontrolled volumes, deranging all the means provided for ventilation, and rendering even the streets offensive and the houses dangerous.

DEPTH OF SEWERS BELOW PAVEMENTS.

In planning the system of sewers here recommended I have paid due attention to subsoil drainage, for it is well known that where the subsoil water has been removed from the foundations of buildings the result has always been to

improve the health of the inhabitants by lessening the amount of consumption and all similar affections. I have, therefore, planned the depth of the main sewers and sub-mains as far below the grade of the street as possible, care having been taken at the same time to guard against an unreasonable outlay to secure the end in view.

In studying what has been done in other cities in this respect, I find that the Commissioners of Sewers in the City of London have decided that the bottom of a common sewer should not in any part be less than twelve (12) feet beneath the surface of the street. The least general depth in Leicester, England, is twelve feet below the surface.

In Boston, Mass., sewers are laid in the suburbs at nine (9) feet below the grade of the street, but in the business part of the city a depth of twelve feet is considered necessary.

In Jersey City, N. J., the depth is twelve feet.

In Newark, N. J., the sewers are generally thirteen feet below the street, but sometimes that depth cannot be obtained.

In Colonel Adams' report to the Commissioners of Drainage of the City of Brooklyn, in 1857, it is stated that the grade of the sewers is to be thirteen (13) feet below the level of the curbstone, and that the same rule is observed in the City of New York. The invert of the pipe sewer is generally one foot less in depth below the grade of the street than that of the brick sewer.

In Cincinnati, brick or main sewers are at a depth of thirteen feet below the streets.

In St. Louis, the least depth is ten feet; but they have had to go as deep as sixty feet to obtain an outfall for one district. In the latter case there is a tunnel.

In Philadelphia, the practice is to make the house-connections with sewers eight and one-half feet below the level of the curbstone, and make the bottom of the connection at spring line of sewer.

Mr. Chesbrough, who is not inferior to any engineer as an authority on the subject, gives it as his opinion that the bottom of a pipe sewer should be ten feet below the grade of the street, but the bottom of a brick sewer should be two feet lower.

A depth of thirteen feet, when practicable, is recommended for this city in the business portion of it where deep cellars are required. In the interior or western portion of the city a depth of ten feet is considered ample.

THE ORDER IN WHICH THE SEWERS SHOULD BE BUILT.

Probably the most urgent matter connected with the proper drainage of the city is the completion of the sewerage of Mission Creek, which has been already commenced by the construction of a very large sewer in the border of the creek from Eighteenth street to Ninth street.

The whole creek should now be filled up from its southerly extremity as far north as Ninth street, and all streets crossing or intersecting the creek should be brought up to the proper grades, so as to allow their sewers to discharge

into the large intercepting sewer with the necessary fall to enable them to be self-cleansing; and the attention of the Board is earnestly called to the immediate necessity of extending the Fourteenth street sewer in a direct line, and connecting it with Channel street sewer, in order to avoid what must otherwise necessarily be requisite, a greater modication of grade in a portion of this district than has been recommended. As the Channel street sewer will carry all the water that flows through the creek, as well as the house sewerage of one of the largest sewer districts in the city, when it is completed, and the lateral sewers connected with it, a very important step will have been taken towards the proper drainage of the city.

In this connection it may be remarked that if this city ever succeeds in obtaining a fixed and permanent sea-wall or bulkhead, an intercepting sewer can be built behind it, after the ground has become sufficiently settled, and the entire drainage of the water front of the city carried to the strong tidal currents off Point San Jose (Black Point), thereby relieving the wharves of all offensive smells, and the slips of nearly all deposits. Such a sewer would have to be of large size. It may be built level, or nearly level. It would require to be flushed at every low tide, the water of every high tide being retained in a proper reservoir for that purpose.

It would be possible, of course, to build such a sewer at the present day; but, owing to the precarious nature of the foundation, its cost would now be so excessive that I have not deemed it proper to recommend its construction until the entire water front is fixed in position and made permanent.

In the construction of new sewers they should be commenced at their outfalls or lower ends and built upwards. The main or arterial sewers should be first constructed. The small pipe sewers can then be built and connected with the main sewers, as the wants of population require.

It should not be forgotten that all sewers projected and shown on the Sewer Map, amounting in the aggregate to about 296.5 miles, 275.5 miles of pipe and 20.8 miles of brick, need not be built in a year, or perhaps ten years. The object has been to present a complete system for the thorough drainage of the city, to be carried out from time to time, as the course of settlement and the wants of population require.

By using smaller sewers than those heretofore used (pipe sewers generally), large enough for all purposes, but no larger than are necessary, the cost per running foot of all the proposed sewers will not be more than one-half, possibly only about one-third of the brick sewers heretofore constructed.

If the city continues the construction of its sewers during the next fifteen years according to the plan now recommended, increasing the amount of funds for that purpose pro rata with the increase of population, and the work be managed economically, it will be found at the end of that time to be one of the best drained cities in the United States.

PUMPING WORKS.

That portion of the city east of Montgomery street, between Jackson and Pine streets, is very badly drained, yet it is the very heart of the business centre of the city.

It is a great misfortune that the grade of Montgomery street, between Jackson and Pine streets, and all that portion of the city eastward of it, had not been fixed at a higher level. But unfortunately the grade of Montgomery street, between Jackson and Clay streets, is only six feet above the city base, which base is only 6.7 feet above high water.

With such a small fall from there to the city front, it is impossible to obtain proper drainage, and the consequence is that the cellars and basements which should be very valuable portions of warehouses, are but little used.

Had the level of Montgomery street been fixed at twenty feet above the city grade, which it is at Bush street, millions would have been saved to the city; and the increased rentals of dry cellars and basements in its commercial centre would have more than paid for the first cost of the higher grade.

There are only two ways of remedying the defective drainage of this portion of the city. One is, by raising the grade of the streets: the other is, by pumping up the sewerage from a lower level than that of the present sewers.

But the value of the buildings on this portion of the city, east of Montgomery street and lying between Jackson and Pine streets, is already so great as probably to preclude the idea of a change of grade. If this point be conceded, then we are forced to resort to pumping works for this district, in order to obtain proper drainage, with dry cellars and basements.

The outline of a system of sewers to drain this portion of the city is shown on a special map herewith. I append a brief description. It is proposed to build a two feet brick sewer along Front street, starting at Pine and terminating in a large masonry tank near the water front, which tank, for illustration, I have located on said map.

This sewer would run beneath all the present sewers, water and gas pipes; its bottom on the inside at Pine street would be at a level of about eleven (11) feet below the city grade, and falling about one foot to each block, it would enter the tank at about twenty or twenty-two feet below the city grade, according to the position of the tank.

One foot pipe sewers, laid at the proper grade below the present sewers, would then convey all house-sewerage within this district to the Front street sewer, these small sewers leading from Montgomery street to Front street, and also from the city front to that street.

The present sewers in this district are to remain undisturbed in order to carry the surface water of rains and the sewage west of Montgomery street, as far as these sewers extend, into the Bay. But all house sewers and drains within the pumping district are to be disconnected from them, and be discharged into the lower or pumping system. In this way, deep and dry cellars may be obtained throughout this important part of the city.

It is supposed that this new system of sewers will be self-cleansing, but if any difficulty in this respect should ever occur, it will be a simple matter to flush them with salt water, without pumping the water, for it will be seen that all these sewers are down to or below the level of low tide. An eight-

inch pipe may therefore be laid at the level of half tide or lower, beginning, say, at the foot of Davis street, extending southward along the water front to the foot of Market street, thence up Market to Pine street, thence up Pine to Montgomery street, thence along Montgomery to Jackson street, the said pipe to have valves, worked from the street level, and so arranged as to discharge the full capacity of the pipe into the head or highest point of every sewer. By this arrangement, this entire system of sewers may be completely flushed every day, or as often as may be found necessary.

The tank into which these sewers discharge must then be pumped out every day, its contents being discharged through an iron pipe into the strong tidal currents at the foot of Front street, or any other convenient place.

This lower system of sewers will be further utilized to drain the ground and the foundations of the houses in this district, by laying blind gravel drains over them, with openings for the subsoil water to enter them at convenient places. As the tide rises and falls in the lower ends of the present sewers, and as they are to convey the rain water of storms, it is necessary, in order to secure dry cellars in this pumping district, that these old sewers be made water tight, and as these sewers are all unnecessarily large, this can be effected by turning a four-inch brick arch, laid in cement, inside of them. The cost of this lining is included in the estimate which follows.

The tank for the reception of the sewage from this district would require to be one hundred feet long, thirty-five feet wide, and eight feet deep below the outlet of the Front street sewer. This would give ample space to hold the sewage of the district from 5 P. M. until 7 A. M. The pump would then be started and the tank emptied by 5 P. M., giving ten hours pumping per day.

For this purpose there should be two independent pumps, with engines and boilers complete, of about twelve horse-power each, so that if, at any time, one pump should get out of order, the other one would be available.

It should not be forgotten that the drainage of this district is entirely independent of the drainage of all other parts of the city. It may or may not be carried out, according to the wish of the property-owners in the district.

Its entire cost, including sewers, man-holes, flushing arrangements, subsoil drainage, lining the present sewers, tank, pumps, engines, boilers, etc., would be about two hundred thousand dollars ($200,000), and the daily cost of pumping and flushing sewers would be about twenty dollars ($20) per day.

Now the interest in the first cost of these works, say:

$200,000 at 10 per cent. per annum	$20,000
Cost of pumping at $20 per day	7,300
Cost per annum	$27,300

or nearly ($75) seventy-five dollars per day.

There are about forty blocks that would be benefited by this system of pumping, and if we suppose that there are or will be forty stores or houses in

each block, we would have sixteen hundred houses upon which the cost would be assessed, or a fraction less than five cents per store or house per day. Whenever the property-owners of this district are willing to pay this amount per day, or eighteen dollars and twenty-five cents ($18.25) per store or house per year, for the privilege of having dry cellars and basements, they ought to be allowed to have them by the construction of the works herein sketched.

The cost of the lot upon which to erect the pumping works is not included in the foregoing estimate.

CHANGES OF GRADE RECOMMENDED.

The established grades in some portions of the city are so clearly defective that I have assumed they must be changed in order to conform to a proper system of drainage.

In a few cases, where the necessity of such changes are perfectly manifest, they are shown on the large Sewer Map; the changes in all such cases being reduced to an absolute minimum compatible with the drainage question before me.

Among the first of these changes which arose in the investigation of this question was the necessity of raising the grade at the intersection of Market and Church streets about 10 feet, or from 73 feet above the city base to 83 feet above that level; and this change is noted on the Sewer Map.

But the greatest change from established grades, which appears to be absolutely necessary, is the raising of the grades within certain limits of Fourth, Fifth, Sixth and Seventh streets. The district within which the changes are to be made are more or less occupied by buildings, and the changes will therefore be more expensive to the property-owners, involving as it must the raising of these houses. To no portion of the question of drainage for the city have I given more attention than the one now under consideration, and the result is that the grades of these streets, within certain limits, must be raised, or else we must resort to pumping the sewage matter.

Channel street sewer is already built from Eighteenth street down as far as Ninth street. It appears to be absolutely necessary that this main sewer should be continued to the bay through Townsend street, for it will never do to concentrate the sewerage of all the upper portion of Mission Bay at Ninth street, where it will be bare at low tide. This would render many blocks in that vicinity practically uninhabitable.

The necessity of extending this main sewer being granted, the question arises, how are we to drain the low portions of Fourth, Fifth, Sixth and Seventh streets, whose sewers now enter into Mission Bay below the level of the main Channel street sewer when extended, and which sewer is as low as it possibly can be placed for efficient drainage?

There are but two answers to this question: one is by pumping the sewage of these streets up into the Channel street sewer; the other is by raising the grades of these streets so that their sewers may have the necessary elevation to discharge into Channel street sewer at the proper level.

I know well that this proposition may meet with opposition from some of the property owners, on account of the expense which it must involve; but let any body of intelligent and disinterested men look into the present defective drainage of these streets, examine the sewers in their lower portions, see that they are full or nearly full of sewage matter which can never be discharged, and reflect that by raising the grades so as to secure proper drainage, the value of property will be greatly enhanced, and I am convinced that it will be their unanimous opinion that the grades ought to be changed.

Knowing the expense involved I have endeavored to make the change a minimum. As this change will interest many persons, I append here the changes in the grades of these streets which are recommended and which are represented on the Sewer Map.

1st. Raise the grade of Fourth street from Folsom street to Brannan street two feet throughout.

2d. Raise the grade of Fifth street from Folsom to Townsend street six feet at Folsom street, eight feet at Harrison street, six feet at Bryant street, and four feet at Brannan street.

3d. Raise the grade of Sixth street from Howard street to Townsend street 3.5 feet at Howard street, 7.5 feet at Folsom street, 7.5 feet at Harrison street, 7.5 feet at Bryant street, and 5.5 feet at Brannan street.

4th. Raise the grade of Seventh street from Folsom street to Townsend street seven feet at Folsom street, seven feet at Harrison street, nothing at Bryant street, but raising five feet at Brannan street. Then the sewers from these four streets can discharge into the continuation of the Mission Creek sewer when it is extended to the bay through Townsend street.

There are other changes of grade which appear to be absolutely necessary, particularly in Townsend and Centre streets; also the intervening portion of Mission Bay. These proposed changes are marked on the Sewer Map. These proposed changes can be more economically effected now than at any future time. There are other and important changes of grades that ought to be made, particularly in the Potrero and South San Francisco.

An examination of the Sewer Map will show that I have planned the sewerage of all these portions of the city where the grades have been established. This is done in accordance with the terms of my contract; yet I desire to say that my studies of the subject of grades, in connection with that of drainage, have led me to the conclusion that a change of grades in these new portions of the city is imperatively demanded, and the sooner such changes are made the better. I beg leave respectfully to urge this matter on the attention of the Board of Supervisors.

The necessity of establishing suitable grades in the new parts of the city and of altering the present established grades where necessary in order to make them conform to a proper system of grades and of drainage, must be manifest to every man who looks a little into the future.

As an illustration, let us look a moment at the Potrero and South San Francisco.

The map of the city shows large areas laid out in Mission Bay, and in the shallow waters of San Francisco Bay at the mouth of Islais Creek; also in the bay still farther south.

If the precedents heretofore established in filling up along the water front of the city are to be continued in the future, the streets through these low lands will only be brought up to the city base, 6.7 feet above high water. If this be done, a proper system of drainage and sewerage will become simply impossible without a resort to pumping.

Immediately adjoining these low lands of the future city, where it is necessary to fill in order to build, are high hills, with, so far as they have been established, inaccessible grades of the streets in many places.

The hill on the Potrero south of Mission Bay rises in one place to the height of three hundred feet above city base, and the hill on the ridge in South San Francisco, south of the mouth of Islais Creek, rises to the height of two hundred and sixty feet above the same level.

The tops of these hills appear to be the proper places for obtaining materials with which to fill up the adjacent low lands, and if they are cut down so as to make the grades of the streets over them convenient and easy and the filling in the shallow waters adjacent to them be brought up so as to make a proper system of drainage practicable, these portions of the city would be greatly improved and the property be rendered vastly more valuable. The ridge south of Mission Bay, and particularly the high peninsula leading out to Hunter's Point, would then become very desirable sites for residences.

Another matter of importance closely connected with this subject is the reconcilation with a suitable plan of streets of several incongruous surveys, with which the new parts of the city are now affected. The streets and roads in some of these surveys are so badly laid out that they can never be made to harmonize with any proper system of streets for the surrounding city.

There ought to be several avenues or new streets laid out in order to afford easy and direct communication with the new portions of the city. These new avenues should follow the lines of natural drainage as nearly as possible, so that while they furnish the natural roads for communication they will also greatly facilitate artificial drainage.

Islais Creek is one of the localities demanding such an avenue. It will not only drain a very large extent of City area in the future, but also a part of San Mateo County, and there must be, in time, a large sewer constructed in or adjacent to the bottom of the valley, to accommodate the drainage, the creek itself being filled up the same as is to be done in Mission Creek.

By the prolongation of Plumas street until it intersects Islais Creek, and then constructing an avenue up the creek to some point near the San Jose Railroad, the objects in view will be accomplished.

Plumas street appears to be the natural outlet for the main sewer, which will eventually become necessary for the drainage of the water shed of Islais Creek. I have, therefore, represented it on the sewer map as being prolonged until it intersects the creek, and have also shown on the map such changes

of grades in the lower portion of the valley of the creek as will become necessary, if this suggestion should be adopted.

There are other new avenues that ought now to be opened, but these need not be touched upon in a report on the subject of drainage, further than to say that such avenues can now be opened at very slight expense, compared with their benefits.

We can do now for the outskirts of the city (soon to become densely populated) for a very little money, and with great benefit to present and prospective values of property, what has recently been attempted at great cost in another portion of the city, by opening Montgomery avenue.

VENTILATION OF SEWERS.

In investigating the subject of the ventilation of sewers, it should not be forgotten that the object of the sewers is to convey away rain-water, sewage matter and sub-soil waters from the sites of our houses.

The object of man-holes is to enable us to maintain a proper supervision over the sewers; to find out places where the sewers may be defective without breaking up the streets to ascertain the position of leakages or stoppages; to cleanse the sewers if necessary, and finally, to afford the means of ventilating the sewers by perforating their covers.

The man-holes in this, and in most other cities, are placed in the middle of the streets, directly over the sewers. By placing ventilators in the middle of the streets we remove the point of the escape of the sewer air to the farthest possible distance from the houses and the passenger traffic on the sidewalks. Besides, sewer gas when escaping in the middle of the street has a better chance of immediate dilution with the atmosphere before it has time to do mischief, than when escaping at any other point.

The object of catch-basins or gullies is to provide the means of receiving rain water, surface and waste water into the sewers. They are placed in the gutters on the sides of the streets close to the sidewalks, usually at the corners, but not necessarily at the four corners as is generally the custom. They should be trapped in all cases; otherwise the sewer air will escape along the sidewalks and become extremely offensive, and at times dangerous. They should connect with the sewer by branch pipes from not less than six inches to twelve inches in diameter, in accordance with the size of the sewer with which they connect.

A trap is a barrier, usually a water barrier, placed between a sewer or drain on one side, and the external or interior air of our houses on the other side. These water-traps usually partake of the nature of an inverted syphon, and are liable to become untrapped from various causes, thereby allowing the escape of sewer gas, which, if the sewer is badly ventilated, is known the world over to be dangerous to health. If it be allowed to escape into our houses, particularly into sleeping apartments, it induces diseases, notably typhoid fevers.

Many people who have not studied the subject tell us, "I am in no danger from this cause of disease; my house stands on high ground; and every pipe from bath-tubs, sinks, water-closets, wash-bowls, etc., are trapped so that no air from the sewers can enter the apartments." The prevalence of typhoid fever in the fine palaces of New York and other cities shows that such opinions are erroneous.

Having said this much, it will be well, perhaps, to show in what manner the sewer gases escape into bedrooms in spite of all precautions.

For the sake of clearness, take the case as it now exists in almost any street in this city; say Jackson, Washington, Clay, California, Pine, or Bush streets, having sewers starting at the top of the hill and running to the bay. Being without any openings for ventilation, they are sealed pipes, into which the house drains empty.

Of course, when first built, they are filled with air; but as soon as they come into use, and water and sewage matter enter into them, some of this air must escape. Each cubic foot of water will displace a cubic foot of air—the water running down to the bay, and the gas ascending to the upper end of the sewer, to escape there, unless ventilators are provided for its escape elsewhere.

Now suppose a heavy rainfall, added to the house sewerage, fills the sewer half-full of water and other fluid matter. The air in the sewer, in that case, if it cannot escape, must become compressed into half its volume, occupying the upper half of the sewer. According to the law of the compressibility of gases, their pressure is inversely as the space occupied.

In the case supposed, therefore (no outlets being provided for its escape), the pressure of the gas in the upper half of the sewer becomes equal to one atmosphere, or to fifteen pounds in a square inch; which is equal to a column of water about thirty-four feet high. No traps can resist such a pressure, and the air must escape through them into our houses. In this way, the constant variation of the quantity of fluid matter entering into a sewer or house drain, or, in fact, into a connected system of sewers, gives rise to corresponding variations of pressure in the gases in such sewers and drains, by which the security of traps are constantly endangered, unless we provide openings for the free exit of the sewer gases, and the free entrance of the outside atmosphere into the sewers.

One of the first things, therefore, to improve the existing sewers of this city is to provide for their proper ventilation through the man-holes into the open streets, so that sewer air may not be forced up through the house drains. This can be easily and cheaply done by perforating the covers of the present man-holes with a suitable number of half-inch holes, through which the gas can escape whenever there is any excess of pressure of air in the sewers and through which free access is given for the external atmosphere to enter and pass through the sewers whenever there is any tendency to a vacuum in them, thus rendering the traps comparatively safe from being sprung, and rendering the sewer gas innocuous, for it is known that such gas when mixed with a large quantity of atmospheric air is comparatively harmless.

While on this subject of sewer gas springing the traps and escaping into our houses, it may be well to state that there are many other forces at work in a sewer besides the one just mentioned. Among these are heat, difference of temperature between the external atmosphere and the internal air of the sewers, barometric changes, vapor of water, winds, position of the outfall of the sewer, friction and leakage. The influence of all these and other causes is discussed in the most recent works on the subject, but as it would greatly add to the length of this report to quote them here, I content myself with merely mentioning them, so that you may know they have not been overlooked. Baldwin Latham's work on Sanitary Engineering contains the most exhaustive discussion on the subject of the ventilation of sewers.

The present man-hole covers in the city, as well as those to be constructed in the future, should be thus perforated; and, to assist further in counteracting the poisonous influence of the gas, recourse has been had in England to the use of charcoal, so placed in the man-holes and other ventilating passages as to render it impossible for the gas to escape without passing through the charcoal.

It is well known that all porous substances have more or less the power of absorbing fluids and of absorbing and condensing gases within their pores. Professor Liebig says, in his letters on chemistry, that one cubic inch of beechwood charcoal contains pores equal in area to one hundred superficial feet. In alluding to the use of charcoal for ventilation, Dr. Stenhouse says: "The efficiency of charcoal appears never to diminish, if it is kept dry and its pores are not choked with dust." Dr. Welcker says: "It (charcoal) possesses the power not only of absorbing certain smelling gases, such as sulphuretted hydrogen and ammonia, but also of destroying the gases thus absorbed, for otherwise its purifying action would soon be greatly impaired. It is very porous and its pores are filled with condensed oxygen to the extent of eight times its bulk. We have, therefore, in charcoal oxygen gas in a condensed and more active condition than in the common air which we breathe. Hence it is that organic matter in contact with charcoal is so rapidly destroyed. The oxygen that acts on organic matter and burns it is speedily replaced, and the process goes on continually."

Charcoal has been used in various ways to assist in the ventilation of sewers, but the most efficient and economical plan hitherto used is the form adopted by Mr. Baldwin Latham in "Latham's Patent Ventilator." This instrument does not obstruct the escape of the gas, although the latter is compelled to come in contact with the charcoal. It affords the most efficient application of charcoal to oxydize sewer gas that is at present known to sanitary engineers, and I recommend its use on the sewerage system of San Francisco, especially whenever the streets are comparatively narrow.

A section of this ventilator may be seen on reference to figure No. 8. It consists,

1st. Of a cover, the central part of which is solid, so as to form an efficient cover for the charcoal and protect it from rain or water used in watering the streets. Around the central or solid part of the cover there are concentric circles formed of open grating, through which air escapes or is drawn into the sewer.

2d. A frame for receiving the cover, and on the bottom of which hangs the dirt box and charcoal ventilator.

3d. The dirt box which hangs in a groove made in the lower part of the frame. A portion of the dirt box is converted into an open spiral trough which is used for conveying away the overflow water from the dirt box to the sewer. There is a slat in the side of the dirt box communicating with the upper portion of the spiral trough, through which the water enters the trough.

4th. A spiral tray for containing the charcoal. This is screwed into the ventilator over the spiral trough by means of a handle attached. Each tray consists of a square central shaft having projecting arms of T iron. These arms are attached at the extremity by a strap of iron coiled spirally, and the bottom of the tray is filled in with net work. The arms divide the whole tray into so many compartments for retaining the charcoal, which in consequence is kept in position, or otherwise it might have a tendency to slide down to the bottom of the tray.

No attention appears to be given to the catch basins in this city, except to build them, and to remove the sand and other substances from them when they become so filled up that the water of heavy rains cannot pass through them into the sewers. They are used more as cesspools than as catch-basins or gullies for water. When cleaned out, they are found to contain substances which they were never intended to receive; such as street dirt, garbage of all kinds, ashes, shavings, sticks, brickbats, coal, bones, bottles, rotten fruit and vegetables, old clothes, boots, shoes and stockings, broken crockery, etc. In some parts of the city dead dogs, cats and rats have been found in these catch-basins. The facility with which their covers can be removed and replaced, particularly at night, invite to this easy way of disposing of all kinds of garbage.

These basins were intended to be kept full of water so that their traps may be sealed at all times.

It should be made the duty of some officer, or of some department of the city government, to see that they are always in order and full of water, and any person found throwing any substance into them should be subjected to a fine.

FLUSHING AND CLEANSING SEWERS.

In the system of sewers which I now propose, and which are represented on the large Sewer Map, I have endeavored to make all new sewers to be hereafter constructed, self-cleansing by their own sewage, by making them of the proper size, and giving them the necessary slope for that purpose.

There are some of the existing sewers of the city, however, which are too large, and laid on too low a grade, ever to become self-cleansing in the dry season of the summer and fall.

This is particularly the case in the present sewers east of Montgomery street, between Jackson and Pine streets. And it may happen that, when some of the new sewers now proposed come to be built, that they will not at

first be self-cleansing. As, for example, a new sewer may be built in certain streets in the new portions of the city before the blocks alongside of the sewer are compactly built up and occupied. If such a sewer drains only a few houses on any one block, it is manifest, for the time being, that there will not be sufficient sewage matter from these few houses to produce the necessary velocity to render such a sewer self-cleansing.

In all such cases—that is, whenever the sewers are not self-cleansing by their own sewage—artificial means must be resorted to, to cleanse them, or rather to remove the deposits that may accumulate in them.

Many expedients have been resorted to for effecting this purpose. The first and most natural one was to send men and boys into the sewers, and remove the deposits from them in buckets through the man-holes in the middle of the streets.

This vile practice still obtains in this city, but it has seen its day and its end in all well drained cities of our Atlantic seaboard and in Europe; and when the true principles which should govern the proper construction of sewers are better understood and acted upon in this city, the disgusting operation will come to an end here also.

The most common and most satisfactory manner of cleansing sewers, whether large or small, is by flushing—that is, by increasing the volume of liquid matter passing through the sewers in a given time.

Flushing is of two kinds:

1st. By making use of the sewage matter itself for cleansing the sewers. This is accomplished by damming up the sewerage within the sewers, and then suddenly liberating it.

This requires an elaborate system of special flushing-gates or sluices fixed in the sewers, to act first as a dam to the sewage and then as a gate giving it free passage. These gates are of various descriptions and are fully described in some of the works on sewerage. They are expensive in construction and require constant care and attention to render them effective.

I apprehend the latter would be the chief objection to their introduction into the sewers of this city. If we have not yet learned to take care of and keep clean the simple catch-basins alongside of our sidewalks, it is fruitless to hope that we will be able to keep in order and operate successfully an elaborate system of sluice-gates fixed in the sewers, where they cannot be seen or worked except by an expert.

After careful examination of all the authorities on this subject within my reach, I cannot recommend this system of flushing sewers in San Francisco at the present time. At best, supposing it to be carried out as perfectly as possible, it is only a poor expedient for cleansing the sewers.

The second method of flushing sewers is by water. It is manifest that sewers can be more perfectly cleansed with pure water than with sewage matter.

There are several ways of introducing the water of a city into its sewers for the purpose of flushing them. One is from the fire plugs of the water mains;

another by pumping the water from tanks with fire engines. Both of these methods would be very expensive here, because they require a large quantity of water.

The true method is to introduce a large volume of water into the sewer for a short time. In this way a sewer will be cleansed with a far less quantity of water than is possible if the water be introduced by driblets.

The method of introducing water into the sewers for the purpose of flushing them varies in different cities. In some cases tanks are provided for water, the contents of which are from time to time discharged into the sewers by means of valves. In other cases cisterns for holding water are constructed, the contents of which are similarly discharged into the sewers. In Dantzic, special supplies of water for flushing the sewers are provided.

The most simple system is to draw the water direct from the water mains into the sewers, by means of pipes of the proper size, having valves which can be opened and closed from the level of the street. In this case, provision must be made to check the velocity of the water, without decreasing its volume, in case the pressure of water in the main is so great as to endanger the safety of the sewer by the water escaping into it.

This method, however, presupposes an abundant supply of water in a city. If the plan now proposed for the drainage of this city is carried out, or so far executed as to provide the proper outfalls for the sewers, we will soon know which sewers will require flushing.

I think provision should be made, as soon as possible, for flushing the lower ends of the sewers from Jackson street to Pine street; and I believe the cheapest and most thorough method of cleansing these sewers at the present time will be to buy water from the Spring Valley Water Company for that purpose. If objection is made to connecting the water mains with the sewers, in order to effect this object in the simplest way, it is probable that the cisterns now constructed along Dupont and Kearny streets can be utilized. By connecting them with the sewers, by large pipes leading from their bottoms down hill, until they can be introduced into the sewers, the whole contents of a cistern can be discharged into the adjacent sewer in a few minutes. In this way, the water that may be used for flushing purposes, in this district, could be accurately ascertained. In all the other districts of the city, I recommend that the flushing arrangements await future necessities.

It is within the range of possibility, before any great outlay will be required for that purpose, that this city may be supplied with an abundance of water, and possibly may own the works herself; in which case, the water for flushing will not have to be purchased, and the arrangements for that purpose may be greatly simplified.

It has been proposed by some persons to pump up salt water from the bay, for the purpose of flushing the sewers, sprinkling the streets, washing out street gutters, and for extinguishing fires, etc. etc.

It is not doubted but such an additional supply of water would possess some advantages in this city at the present time, but it would duplicate the

system of water pipes, and as the water would have to be pumped, it would, in the end, probably be found more expensive than to purchase water from the Spring Valley Water Company for these purposes, even at present rates. When an additional supply of water for this city is introduced, either by a private company or by the city itself, as must be the case in a few years, the price of water must necessarily be so greatly reduced that it may be used lavishly for all the purposes above named without its use being felt as a tax on the City Treasury.

In this connection it should not be forgotten that when the sewerage system is so far completed that all connections with the outfalls of sewers are made, there will be but little flushing required, and if water were abundant, and proper connections between the water mains and the sewers established, very few men would be required to flush the sewers. Probably two, or at the most three men, would be sufficient for the entire city.

The expense of three efficient men need not be more than four thousand dollars per year, and the sewers would then be thoroughly cleansed; whereas the city now pays fifteen thousand per year for this purpose, and the sewers are not half cleansed.

For the reasons above stated, I cannot recommend the pumping of salt water for the purpose of flushing the sewers and sprinkling the streets at this time.

The sewers should be flushed at night, when the water in the water mains is not required for other purposes, and when the effect of disturbing the sewage and gas in the sewers will be least perceptible.

Pipe sewers are too small for a man to enter them. If, therefore, they require cleaning some other method must be resorted to. It has been found in our Eastern cities, and in European cities where pipe sewers have been extensively introduced, that they can be kept free from deposits, and need not therefore be entered. Baldwin Latham, in his work on "Sanitary Engineering," says: "There is no more necessity to send men into sewers to carry out such disgusting operations, than there is to send boys up chimneys to sweep them."

As there ought to be a man-hole or lamp-hole at every change of direction or change of grade in a sewer, it is manifest that if the sewer is clear, by lowering a lamp into the sewer through such man-hole or lamp-hole, we can see from man-hole to man-hole, and discover the location and nature of any deposit, obstruction, or defect in the intermediate sewer.

Proper tools must be provided for clearing out any deposit in the pipe sewers. These tools are of various kinds, jointed and made to fit the form of the sewer, or to properly take hold of the obstruction to be removed. A description of these tools can be found in Baldwin Latham's work on sewerage.

HOUSE-DRAINAGE.

The construction of house-drains in this city depends at present upon the property-holders, each one building his own drains as he thinks best. House

drains are, therefore, private property; but, in a sanitary point of view, what concerns one citizen concerns all. I cannot, therefore, be considered as touching on private rights by devoting a few words to this subject.

The efficiency of a system of sewers is dependent on the house drains and minor sewers which convey the waste water from the houses to the sewers; but if these tributaries fail to perform the duties required of them, the sewers either remain idle or are comparatively useless, and all the care bestowed on them is in vain.

Baldwin Latham, in his celebrated work on "Sanitary Engineering," says: "The work of house-drainage is the crowning point of a system of sewers. Upon the care and skill bestowed in carrying out this portion of the sanitary requirements of a district in a great measure will depend the ultimate success of the works in a sanitary point of view. It cannot be overlooked that imperfect sanitary works in connection with the houses in which we reside will result in the malarious influence of the sewers and drains being brought to bear directly upon their occupants. As a rule the works of house-drainage are carelessly and thoughtlessly carried out, and often inflict untold injury on the luckless occupants of the house in which they are executed. It should be said that the train of evils which often follows the improper execution of house-drainage works is not due, generally speaking, to the character of the workmanship, but to faults in principle in the arrangements adopted.

"House-drains are intended to carry away from the houses all liquid refuse, waste surplus water, and fæcal matter, and while performing this duty, they should be so designed and constructed as to prevent the entrance of sewer gas into the house. The rate of flow through house-drains is liable to considerable fluctuation, and the temperature varies greatly; and these two causes, as already pointed out, of necessity require that ample ventilation for the drains shall be provided."

J. Herbert Shedd, in his report on sewerage in the city of Providence, says: "No amount of skill, care and expense in building the public sewers will relieve the property-holder from the necessity of constructing his private drains with all possible care. These drains often cause in the aggregate more trouble on account of imperfect plan and construction than all the rest of a sewerage system.

"To keep the sewer gases out of houses it is not enough to place water traps at the various inlets of the house-drain itself. The compression of the air in the drain, which may often arise from many causes, will blow through any practicable traps at the inlets throughout the house, and the vacuum which has a tendency to form every time a large amount of water is thrown into the lower part of a house-drain makes a suction upon every trap that is above it. In this way the water is often drawn out of such traps, and until they are again filled with water, a communication is opened for the passage of foul air into the rooms. Any imperfections at the joints of the drain will also allow such communication. There may be a dangerous amount of sewer air in the house without its presence being suspected, as, in its worst forms,

it is not necessarily of strong odor, nor in any way of a character to force itself on our attention. To prevent these evils there should be a systematic provision for constant ventilation in the drains, of such a character that the tendency would be rather for a draught from the house into the drains than from the drains into the house.

"The first requirement is to shut off, as far as possible, all communication for air from the public sewer to the house drain; so that, whatever the mismanagement of the sewers, either in construction or cleansing, the householder may be reasonably protected."

For this city, I would recommend Mr. Shedd's principle of house-drainage; and the drawings herewith submitted, with the Sewer Map, illustrate the plan which he recommends. I append a brief description:

"The trap in the house drain, above referred to, is placed just outside the walls of the house. Immediately back of it, between it and the house, the down spout for carrying rain-water from the roof enters the house drain." Again: "From the highest part of the soil-pipe within the premises, a pipe of the full size is carried to a point above the roof of the building, making another open communication with the outer air. These two pipes, with the drain, form a syphon; and, under all ordinary circumstances, there will be a constant flow of air down the cooler leg and up the warmer leg, keeping up a circulation of considerable value. Now, if the compression of air in the public sewer blows through the lower trap in the drain, the sewer air has a free escape to the outer air, without causing an injurious pressure on the traps of the various inlets to the drain; and a sudden rush of water poured into the lower part of the drain is followed up by the outer air through one leg of the syphon, so that no vacuum can be formed sufficient to suck the water from the inlet traps. In the case of heavy rain, when the down spout is filled with water, no injury is done, but only a cessation occurs, for the time, of the flow of outer air through the syphon."

"Private drains are often obstructed by carelessness on the part of those using them, in admitting substances which they were not intended to receive."

"Perhaps the most common and the most certain cause of obstruction to house-drains arises from grease, which, though fluid when it is hot, soon cools in the drains, and gradually but certainly closes them up. I have known drains from thirty to fifty feet in length closed nearly the whole distance from this cause; the amount which will collect from the waste of a single family is surprising to those who are not familiar with the subject. It ordinarily causes much more expense and inconvenience to allow this substance to run into the drain than to catch it in a grease-trap, from which it can be conveniently removed."

A trap for this purpose is shown on the sketch illustrating "house-drainage." The proper position for a grease trap is under the sink. Of course, the joint between the body of the trap and the cover must be well sealed in order to prevent any sewer air from escaping.

The material to be used in the construction of the house-drains should have as smooth a surface as possible. It will then cause the least amount of friction, and consequently the least impediment to the progressive motion of its contents. The internal projections and the many impediments to the flow of sewage which are unavoidable in a brick drain, force upon us the necessity of looking for a material which will guarantee a smoother surface, and which will also afford the assurance of impermeability without being subject to the frequent patchwork to which the numerous interstices of a brick sewer always render it liable. Glazed earthenware pipes of six inches diameter for a house of ordinary size are recommended as capable of obviating all these difficulties. For factories, hotels, and other large buildings, the size should be increased.

In laying house-drains, great caution should be observed in making proper connections with the street sewer. These connections must be so effected as to prevent any upward motion of their contents when the sewers become surcharged, and they should be made so as not to obstruct in any way the flow of the sewage.

To accomplish this end, they should in all cases be made to connect with the sewers at acute angles considerably down stream.

Connections between house-drains and sewers should be always made by a competent person. This is a matter which requires much care and attention, for the reason that most of the sediment in the sewers is caused by the objectionable manner in which these connections are generally made.

If the axis of the lateral is below that of the main sewer, or if it has not an increased inclination for the curve, deposit will take place. At the point of connection the axes of both sewers should be, if possible, on the same level, and be made to connect down stream at acute angles of not more than forty-five degrees, or less than thirty-six degrees, and the curve on a radius of not less than twenty feet.

To facilitate the means of connecting the house-drains with the sewers, the latter, if pipes, should have lengths inserted at convenient distance having outlet sockets for receiving the ends of the house-drains, and these being slightly tapered, or conical in form, will be easily jointed with cement. In brick sewers, facilities will be afforded for connections with the house-drains by inserting a socket of stoneware to receive the drain pipe. This socket should be formed with a flange at the other end to surround and cover the opening in the sewer, which can then be made good with a ring of cement.

When sewers are to be laid in the streets which have not yet been entirely occupied with buildings, it is proposed to have the sockets for house-connections inserted at intervals of twenty-five feet, and to have them plugged until they shall be required to be used; this will obviate the necessity of tampering with the walls of the sewers, and thus prevent the danger of injury in every case where a proprietor may require to connect his house-drains with the sewers.

The civic authorities should exercise a surveillance over the mode of laying house-drains and connecting them with the sewers by licensing a competent

officer to discharge these duties, and exacting bonds as a guarantee for the faithful performance of the work—permits for that purpose being made always necessary when a connection is to be made. With these precautions there will be a guarantee of the sewers being properly laid, and all the details properly executed.

Although house-drains are laid at the expense of the owners of the premises to be drained, it has been found necessary in all large cities to establish rules by which such work must be done, under the immediate inspection of some competent officer. "These instructions," says Shedd, "have been proved by experience in many cities to be necessary to secure housekeepers from the great annoyance to which they would be subjected from imperfect arrangement or unfaithful execution."

The experience in Chicago is thus expressed by Mr. Chesbrough: "As the usefulness of the sewers depends so much upon the faithfulness with which house-drains are laid, past experience shows that this work ought never to be put into the hands of unfaithful or irresponsible persons. In some cases not only individuals have suffered much annoyance, as well as loss, but the sewers have had to be cleansed at an otherwise needless expense."

"Probably no system better than licensing competent and faithful persons can be devised; but great caution should be used in granting the licenses, for the fact of unfaithfulness is not likely to be known in many cases till its consequences appear, which may not be for a year or two after the work is done, and the doer out of the city."

In order to furnish useful hints as to the proper rules to be established in this city under which private drains should be laid, I append to this report a copy of the rules for laying drains which have been established in the City of Providence, R. I., copied from the work of Mr. J. Herbert Shedd.

"A COPY OF RULES FOR LAYING PRIVATE DRAINS IN THE CITY OF PROVIDENCE, R. I.

"*Application for Private Drains.*

"1st. Applications for permits to connect with any sewer which has been constructed, or which is in process of construction, by a committee appointed by the Board of Aldermen, must be made in writing to the Water Commissioners by the owners of the property to be drained, or by their duly authorized attorneys, and must be accompanied by a clear description of the premises to be drained, and the drains required; and also by certain agreements, all as provided in the printed form of application issued by said Commissioners.

"2d. No one but a drain-layer duly licensed by the Water Commissioners will be allowed to make connections with the public sewers named in the above section, nor lay any drains in connection therewith.

"3d. At least twenty-four hours notice must be given at the office of said Commissioners before any street or public way can be opened for the purpose of laying a private drain.

"4th. No drain-pipe can be extended from work previously done and accepted, or new connections of any kind be made with such work, unless previous notice of at least twenty-four hours is given to the engineer in charge of private drains.

"5th. No work of laying drains can be commenced or continued unless the permit is on the ground, in the hands of the drain-layer, or some one employed by him.

RULES FOR LAYING DRAINS.

1. In opening any street or public way, all materials for paving or ballasting must be removed with the least possible injury or loss of the same, and, together with the excavated material from the trenches, must be placed where they will cause the least practicable inconvenience to the public. As little as possible of the trench must be dug until the junction piece into the sewer is found, unless it is first determined to make a new opening into the sewer.

2. Whenever the sides of the trenches will not stand vertically, sheeting and bracing must be used to prevent caving.

3. No pipes or other materials for the drains can be used till they have been examined and proved by the Chief Engineer, or by one of his assistants, or by a duly authorized inspector.

4. The least inclination that can be allowed for water-closet, kitchen, and all other drains of not over six inches diameter, liable to receive solid substances, is one-half inch in two feet; and for cellars or other drains, to receive water only, one-quarter of an inch in two feet, all drains to be laid at a grade of not over one-half an inch in two feet between the sewers and the sidewalks.

5. The ends of all pipes not to be immediately connected with water-closets, sinks, down-spouts, or catch-basins, are to be securely guarded against the introduction of sand or earth, by brick and cement, or other water-tight and imperishable materials.

6. All pipes that must be left open to drain cellars, areas, yards, or gardens, must be connected with suitable catch-basins of brick, the bottoms of which must not be less than two and a half feet below the bottom of the outlet pipe, the diameter not less three feet, and the form and construction of which are to be prescribed by the officers named in the third rule; when meat packing-houses, slaughter-houses, lard rendering establishments, hotels, or eating-houses, are connected with the sewers, the dimensions of the catch-basins will be required to be of a large size, according to the circumstances of the case. When the end of the drain-pipe is connected with a temporary wooden catch-basin for draining foundations during the erection of buildings, the drain-layer will be held responsible that no dirt or sand is carried into the drain or sewer from such temporary catch-basin.

7. No private catch-basin can be built in the public street, but must be placed inside of the line of the lot to be drained, except when the sidewalks are excavated and used as cellars.

8. No privy-vaults can be connected with the sewers, except through an intervening catch basin, and the discharge-pipe of the vault must be high enough above its bottom to effectually prevent anything but the liquid contents of the vault from passing into the drain.

9. The inside of every drain, after it is laid must be left smooth and perfectly clean throughout its entire length.

10. In case it shall be necessary to connect a drain-pipe with a public sewer, where no junction is left in said sewer, the new connection with such sewer can only be made either by one of the employees of the Commissioners, or when an officer named in rule third is present to see the whole work done.

11. Whenever it is necessary to disturb a drain in actual use, it must in no case be obstructed without the special directions of one of the officers named in rule third. No pipe-drain can be laid above the bottom of a wooden drain, whether in actual use or not, unless the pipe is made to rest either on brick or stone, or other suitable support. In no case will drain-pipes be allowed to rest on wood or other perishable material.

12. The back filling over drains after they are laid, must be puddled, and together with the replacing of ballast and paving, must be done within forty-eight hours after the completion of that part of the drain lying within the public way, and done so as to make them at least as good as they were before they were disturbed, and to the satisfaction of the Commissioners and their Engineer, and the owner will be held responsible for any subsequent settlement of the ground. All water and gas pipes must be protected from injury or settling to the satisfaction of the Engineer.

13. Every drain-layer must enclose any opening which he may make in the public streets or ways with sufficient barriers, and must maintain red lights at the same at night, and must take all other necessary precautions to guard the public effectually against all accidents from the beginning to the end of the work; and can only lay drains on condition that he shall use every precaution against accidents to persons, horses, vehicles, or property of any kind.

14. In case a water-pipe or gas-pipe should come in the way of a drain, the question of passing over or under the water or gas pipe, or of raising or lowering it, must be determined by one of the officers named in rule third. In no case can the drain layer there be allowed to decide the question for himself.

15. No exhaust from steam-engines can be connected with the private or public drains, and no blow-off from steam-boilers can be so connected without special permission from the Commissioners or their Engineer.

16. Such information as the Commissioners have with regard to the positions of junctions will be furnished to drain-layers, but at their risk as to the accuracy of the same.

17. When any change of direction is made in the pipe, either in a horizontal or vertical direction, curves must be used; no pipe can be clipped in any case.

18. All persons are required to place an effectual trap in the line of drain

just before it leaves the premises, and to make an open connection with a down spout back of the trap; also to make an open connection with the highest part of the soil pipe within the premises, through a large pipe or flue, to a point above the roof of the building.

19. Every person violating any of the provisions of the foregoing rules shall pay a fine of not less than twenty, nor more than fifty dollars."

I cannot complete this report without referring to the assistance rendered on the work by B. S. Alexander, Lieut.-Col. of Engineers, Bvt.-Brig.-Gen., U. S. A. To him I am under great obligations for his many valuable and practical suggestions.

To Mr. Guerin, and other assistants, for the faithful attention to the duties assigned them, I am under obligations.

The following is a list of the maps and drawings accompanying this report:

1. Sewer Map of the City and County.
2. Sewer Map of South San Francisco.
3. Sewer Map of the Pumping District.
4. Map showing Connections of Lateral with Main Sewers.
5. Map showing Sewer with House Inlets.
6. Map showing Manholes.
7. Map showing Catch Basins.
8. Map showing Ventilator in Manholes.
9. Map showing House Ventilation.

[Maps 7, 8 and 9 are omitted in this report, but are on file in the office of the City and County Surveyor.]

All of which, with letter from Gen. B. S. Alexander approving said system, is respectfully submitted.

WM. P. HUMPHREYS,
City and County Surveyor.

SAN FRANCISCO, CAL., May 22, 1876.

WM. P. HUMPHREYS, CITY AND COUNTY SURVEYOR:

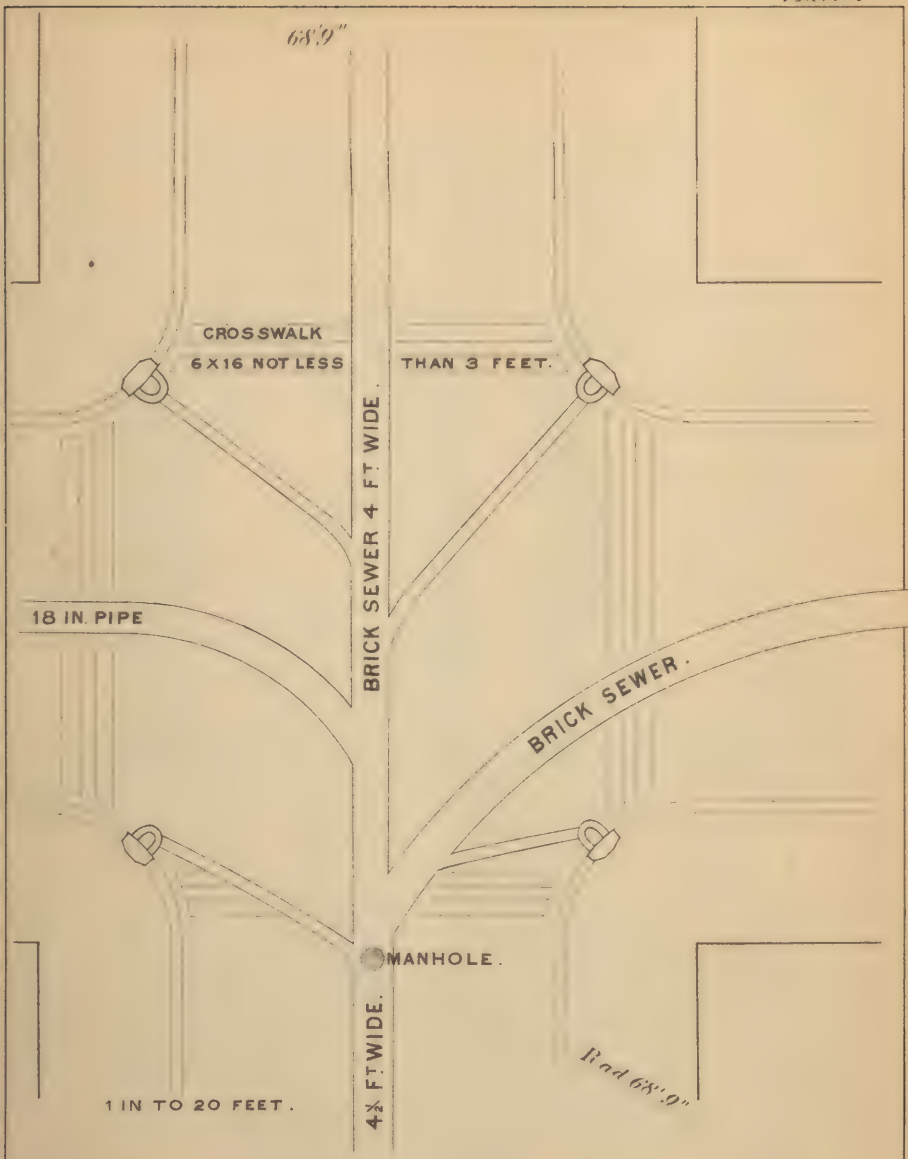
Dear Sir—In reply to your note of the 20th inst., I can state that I have carefully examined the plan which you have prepared for a complete system of sewers for the drainage of this city, together with all the accompanying drawings.

They all meet my entire approbation.

I have also carefully read your report on the subject. I think it presents the necessity, advantages, and mode of obtaining a proper system of sewerage for this city in a very clear and forcible manner.

Very respectfully, your obedient servant,

B. S. ALEXANDER.



STREET CROSSING

SHOWING CONNECTIONS OF

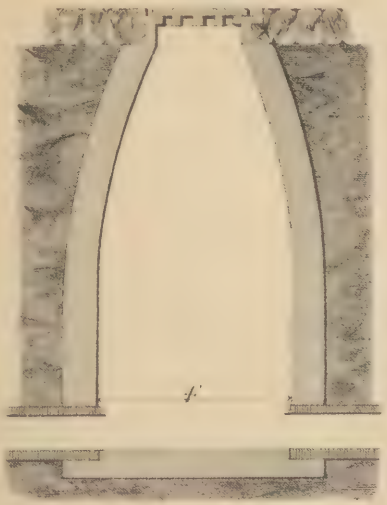
LATERAL SEWERS WITH MAIN SEWER

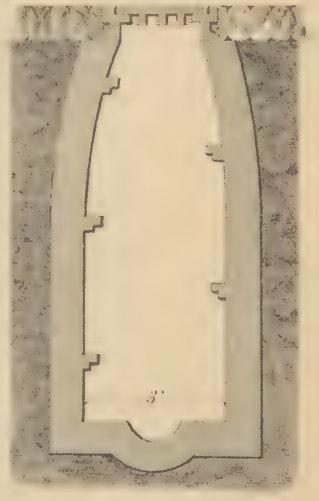
ALSO

CROSSWALKS AND BRANCH PIPES FROM CESSPOOLS.

1 IN TO 20 FEET.

SECTIONS OF MANHOLE.

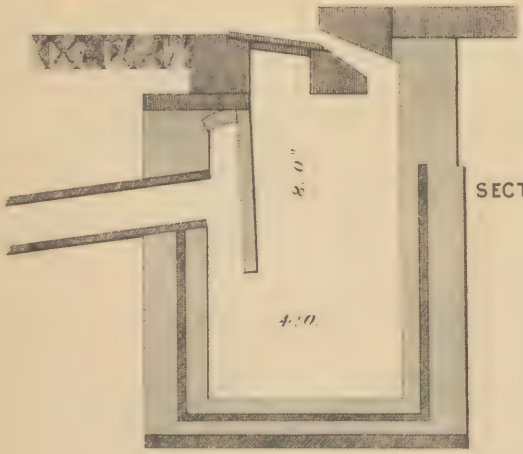




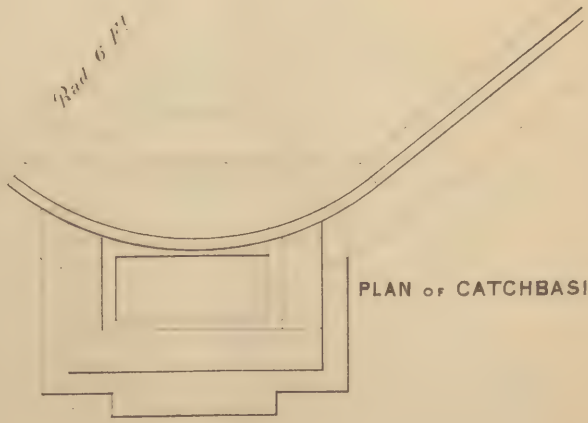
PLAN OF MANHOLE.

COVER.

1 IN TO 4 FEET.



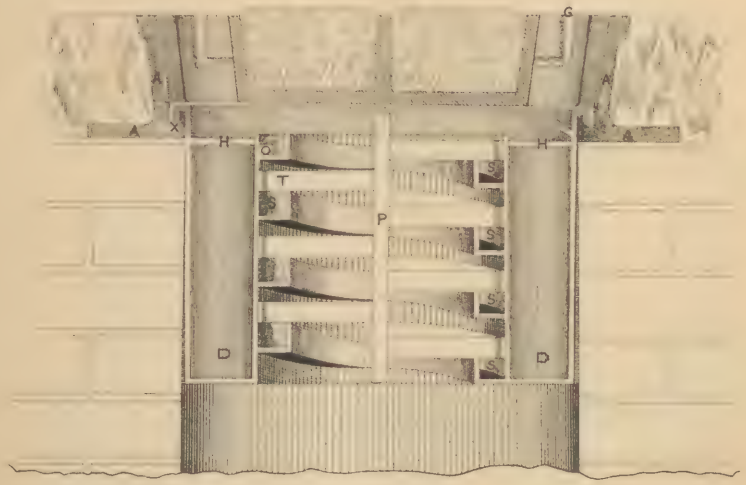
SECTION OF CATCHBASIN.

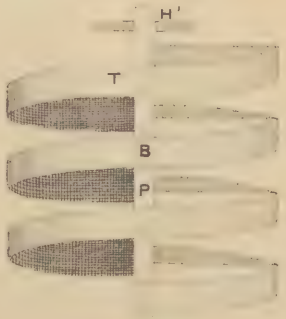


PLAN OF CATCHBASIN.

1 IN TO 4 FEET.

VENTILATOR
FOR
SEWERS AND DRAINS.



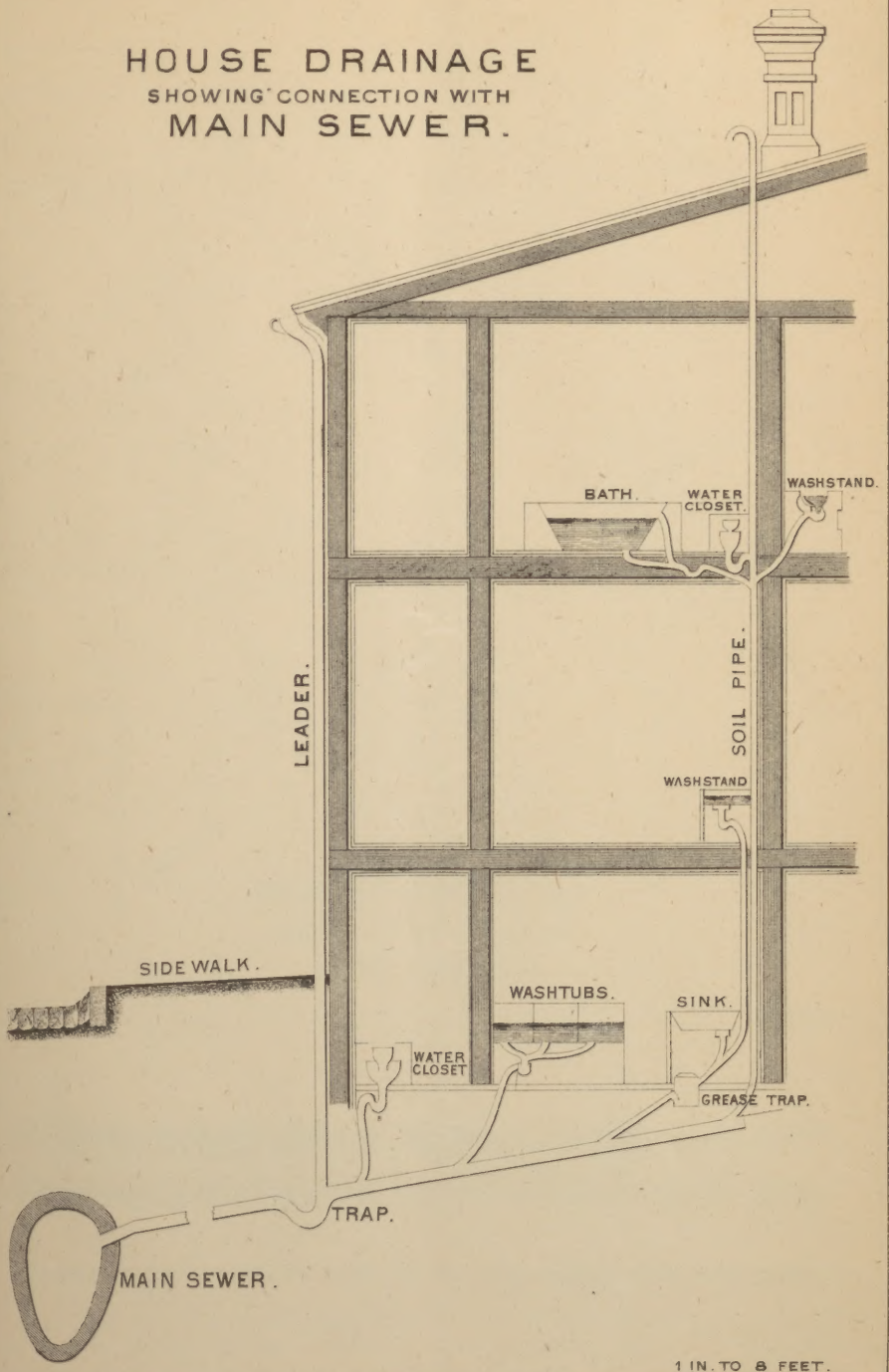


Explanation

A. *Frame for receiving the cover.*
C. *Cover.*
D. *Dirt box hanging in groove* X.
G. *Open grating in the cover.*
H. *Handle to the Dirtbox.*
O. *Slot in the side of the Dirtbox.*
P. *Central Shaft being Square.*
S. *Open Spiral trough*
T. *Spiral trays containing Charcoal*
B. *Arms of* T *-Iron.*
H'. *Handle to Charcoal tray.*

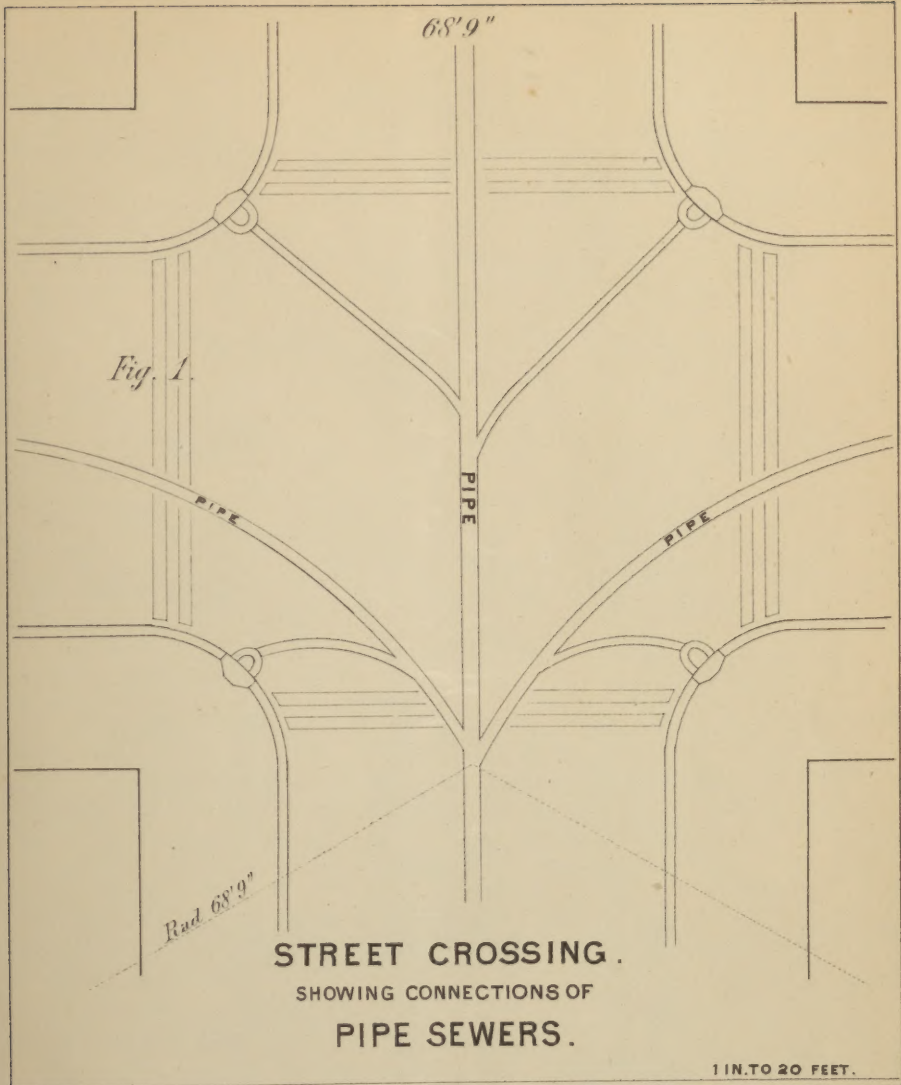
1 IN TO 1 FOOT.

HOUSE DRAINAGE
SHOWING CONNECTION WITH MAIN SEWER.



1 IN. TO 8 FEET.

WITH & T BROWN & CO. B. F.



STREET CROSSING.

SHOWING CONNECTIONS OF

PIPE SEWERS.

1 IN. TO 20 FEET.

Fig 2.

CONNECTION OF INLETS FOR HOUSE DRAINAGE WITH MAIN SEWER.

1 IN. TO 10 FEET.

LITH. G.T. BROWN & CO. B.F.